Using drone technology for preserving the economic sustainability of the agricultural holdings

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Abstract

In the present era, precision agriculture, through the set of innovative technologies that it uses, allows to effectively manage the terrain, machinery, and input acquisition, considering the specific natural variation of the environmental conditions. One of such innovations is the unmanned aerial vehicle (drone) technology which has gained popularity and has been widely used in adopting efficient strategies for preserving the economic sustainability of the agricultural holdings. The need for an efficient management, the complex climatic, technological, economic, and biological changes that have recently occurred at the level of agro-systems impose a continuous and accurate knowledge of the growing production resources and the vegetation state in cultures. In this context, the article investigates a series of particularities regarding the use of geospatial and informational technology in the process of taking, storing, analyzing, and interpreting them to optimize inputs, considering the state of the crops and the degree of soil supply in each relatively homogeneous area of the terrain.

Keywords: economic sustainability, precision agriculture, unmanned aerial vehicle.

1 Introduction

This article is based on the certainty that humanity is living in a limited resource environment, which is currently under major pressure from climate change and population growth. It requires the production, use and promotion of knowledge in the direction of the adoption of new models, at the level of production and consumption processes, to implement the principles of biology and ecology in economic development. One of the aims of this research is to assess the possibilities for the agricultural sector to cope with the pervasive and incisive challenges posed by climate change, population growth and the limited nature of resources, especially the limited availability of agricultural land and freshwater reserves. The impact of these challenges on the need for sustainable agricultural development is major given that agricultural production must increase by 70% by 2050 to respond positively to the food needs of a population expected to reach 9 billion at that time [1]. Relevant options for a favorable response to the highlighted challenges can be identified using information and communication technology (ICT) services, the Internet of Things, but especially unmanned aerial vehicle (UAV) technology associated with image data analysis [2]. The use of information and communication technology services results from the need to aggregate and process information from multiple sources; the use of remote sensing techniques and image analysis allow the assessment of the health of vegetation and is done by aerial monitoring of crops with the help of UAVs, manned vehicles and satellites and the subsequent processing of images captured by them [3,4]. Knowing that satellite imagery is expensive and often has unsatisfactory image quality, and aerial imagery captured by manned aircraft although at a good resolution is costly, we will promote access by agricultural enterprises to aerial crop monitoring services with the help of so-called UAVs and drones, because it offers good resolution images at affordable costs. Thus, agricultural enterprises are encouraged to adopt a smart approach to specific activities, to promote the concept of precision agriculture, which involves the development and implementation of innovative technologies and the use of smart aggregates to carry out / improve activities efficiently and effectively [5]. The impact of drone use is positive because it provides real-time information on areas affected by disease and pests; the variability of the crop's reaction to the action of stimuli such as: irrigation, herbicide, fertilization; contributes to the reduction of the quantities of plant protection products [6,7,8,9], the correct estimation of biomass [10,11,12] etc. The images collected by the drones are processed with the help of software dedicated to assessing the state of vegetation of agricultural crops by obtaining vegetation indices: global vegetation index (GVI); Vegetation Index with Normalized Differences (NDVI); green standardized vegetation difference index (GNDVI); adjusted soil vegetation index (SAVI) etc. The most widely used of these is NDVI (Normalized Difference Vegetation Index) and Near Infrared (NIR) 800 nm. Its usefulness lies in assessing the development and density of vegetation as a result of estimating biomass, green intensity (Greenness), production, fraction of active radiation absorbed in the process of photosynthesis (fAPAR), leaf surface index (LAI), identification of dominant plant species etc. [13,14,15].

2 Research methodology

The present research focused on the descriptive aspect of the problem, ensuring the understanding of aerial monitoring of agricultural crops with the help of drones and the explanatory part focused on identifying variables and their relationships [16]. Due to the complexity of the studied issue, the research was conducted according to the case study methodology recognized by the ability to provide an accurate picture of current phenomena and to understand the causes that determined them, respectively by adaptability to territorial specificity [17].

The research methodology was based on the direct study of the ways of collecting data from secondary sources such as literature, and main through field experiments; of the methods of processing with the help of software, respectively of their interpretation, use and storage. The case study was carried out on the land of the agricultural enterprise SC Agri-Trade Oravița SRL located in the S-W of the country, in Caraş-Severin County and consisted in highlighting some particularities regarding aerial monitoring of agricultural crops and real-time signaling of changes and vulnerabilities in agroecosystem.

The main objective of the research is to highlight the role of taking real-time information on the state of vegetation of agricultural crops and their location underlying the decisions of the company's management. For this, several research directions were pursued: the review of the specialized literature regarding the use of drones in agriculture; organizing field research for the operation and retrieval of information using drones equipped with multispectral sensors; information processing using software and their interpretation; use of the results obtained.

The DJI Phantom 4 drone was used in the aerial crop monitoring action (fig. 1). The drone's guidance system is based on GPS, each recorded photo having correlated geographical coordinates (in the WGS system) of the camera's position. The flights were made at a height of 50 m, according to a flight plan made by selecting a terrain area on a Google Earth or Map support (fig.2).

Figure1. Drone DJI Phantom 4

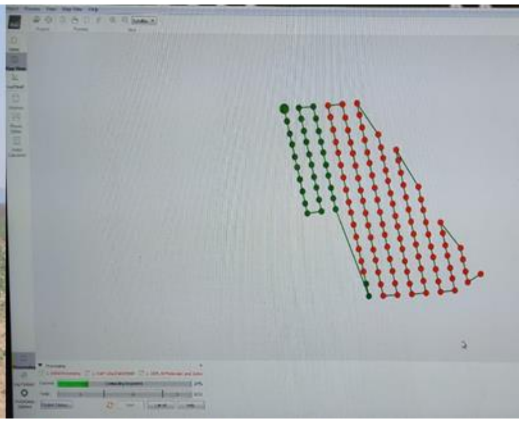

Figure 2. Flight plan

3 Results and discussion

The case study carried out within the agricultural enterprise SC Agri Consorțium SRL highlights a series of particularities regarding the implementation of precision agriculture. These belong to the field of agrophytotechnics and artificial intelligence. Those of agro-phytotechnical nature reside in the structure of crops, specific to the phytotechnical agroecosystem, represented by the following crops: wheat, oats, corn, rapeseed, sunflower, soybeans, peas, alfalfa constituted in a crop organized for four years covering an area of 4540 ha.

The peculiarities of adopting artificial intelligence in production and management processes stem from the use of IoT technology, wireless sensor networks and UAVs for data collection, processing, interpretation of results and choice of optimal decision options. The whole process leads the agricultural enterprise to adopt a resource management based on proportional management taking into account the need for plants that can vary spatially and temporally [18].
To highlight these features, a field research was organized for the operation and retrieval of information using drones equipped with multispectral sensors. The multispectral images obtained were processed using agisoft and global mapper software, which allowed obtaining relevant data that underpinned the company's management decisions that led to the judicious allocation of inputs [19]. Picking up information with the help of the Phantom 4 drone was done from a height of 50m according to a flight plan by selecting a terrain area (the analyzed plot) on a Google Earth support.
The interval between the photos, their number and the distances between the drone's routes is directly related to the flight altitude and is automatically calculated for a correct overlap and obtaining the orthophoto plan in fig. 3. It is georeferenced and is an important source of information on topographic measurements. plant density and health, quality of agricultural work, etc. It also contains the set of information necessary to assess the state of vegetation after processing them with the help of the mentioned software and to obtain the vegetation index with normalized differences NDVI. Monitoring the differences in NDVI leads to critical solutions at an early stage regarding the vegetation saturation of agricultural crops.
The information obtained from the capture of images using drones and their software processing is also used in the creation of a geographic information system (GIS). Within the agricultural enterprise SC Agri Consorțium SRL, it fulfills the role of geographically referencing the cultivated plots of land, ie of corresponding to the reality in the field. The GIS software used is called pmx_AgroLand and works with software called Agronavia.
The adoption of this geographical information system responds to the need for farms to record and manage data on cultivated areas, obtained production, agricultural inputs used to provide summaries and reports to state institutions, respectively to support and guide the farmer in decision-making on development, implementation and innovation. in the specific technological process.

Figure 3. Field image and orthophoto plan

4 Conclusions

The present research highlights the role of artificial intelligence in the optimal management of inputs and ensuring the sustainability of agroecosystems. The adoption of artificial intelligence in specific activities is encouraged and involves the development and implementation of innovative technologies and the use of smart aggregates to perform / improve activities in terms of efficiency and effectiveness. The impact of drone use is positive because it provides real-time information on areas affected by disease and pests; the variability of the reaction of the culture to the action of some stimuli, the correct estimation of the biomass, etc.

The images collected by the drones are processed with the help of dedicated software for assessing the state of vegetation of agricultural crops by obtaining vegetation indices. The most widely used of these is NDVI.

The case study was carried out on the land of the agricultural enterprise SC Agri-Trade Oravița SRL located in the S-W of the country, in Caraş-Severin county and consisted in highlighting some particularities regarding aerial monitoring of agricultural crops and real-time signaling of changes and vulnerabilities in agroecosystem. Picking up information with the help of the Phantom 4 drone was done from a height of 50m according to a flight plan by selecting a terrain area (the analyzed plot) on a Google Earth support. The information obtained from the capture of images using drones and their software processing is also used in the creation of a GIS.

The adoption of the GIS system allows the recording and management of data on cultivated areas, production obtained, agricultural inputs and the preparation of specific reports, and the adoption of optimal decisions.

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